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ABSTRACT

The purpose of this investigation was to compare the effects of brief treadmill exercise and meditation with a placebo-control treatment for reduction in several physiological and psychological measures of stress, anxiety, and tension before and after a written final examination in 48 high-test anxiety subjects. The subjects, 24 men and 24 women, were divided into three groups for testing purposes. Group 1 spent 20 minutes in moderate treadmill walking; group 2 spent 20 minutes meditating quietly and relaxing muscles; group 3 were each given a pill, purportedly double-blind, potentially a tranquilizer pill, in reality, a placebo. Tests were made for resting heart rate, systolic and diastolic blood pressure, frontalis muscle tension, and electrodermal response. Results indicated that brief mild exercise may be more effective in coping with stress than quiet meditation to a slight degree. The tranquilizer (placebo) appeared to be the least effective method of reducing anxiety. (JD)

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A COMPARISON OF EXERCISE AND MEDITATION IN REDUCING PHYSIOLOGICAL RESPONSE TO STRESS

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ABSTRACT

The effect of treadmill exercise and Benson's Meditation was compared with a placebo treatment for reduction of resting heart rate (HR), systolic (SBP) and diastolic (DBP) blood pressure, frontalis muscle tension (EMG) and electrodermal (EDR) response to a mild stressor prior to a written final examination. Observations were made at baseline, after the stressor and post-treatment. Values for state anxiety were recorded at baseline and post-treatment. A population of 400 university students were screened for symptoms of excessive tension and anxiety associated with impaired performance on written examinations. Forty-eight high test anxiety students were randomly assigned to one of three treatment procedures which included: 1) treadmill exercise at HR=100-110 BPM for 12 minutes with 8 minutes recovery 2) meditation according to Benson (1975) for 20 minutes and 3) a placebo pill (purported to be either tranquilizer or placebo, double-blind) followed by a 20 minute rest period.

The results showed that exercise treatment produced a significantly greater decrease ($P<.05$) in HR, EMG and EDR than the placebo group. The meditation treatment produced a significantly greater decrease in EMG than the placebo group. There was no significant difference between treatment effects of exercise and meditation for EMG. There was no significant difference among treatments for SYS or DIA. State anxiety levels were markedly decreased for both exercise and meditation treatments, though significant differences were not observed. These results suggest that brief mild exercise has a potent effect in reducing physiological response to an acute stressor. Meditation appears to have some beneficial effect in reducing muscle tension.

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INTRODUCTION

The benefits of exercise as a relaxant or as a method of relieving stress and tension have been alluded to frequently by the growing population of exercise enthusiasts. Numerous studies have been conducted on the physiological and psycholcgical benefits of exercise, but the evidence to date has not adequately explained the "subjective benefits" in objective and quantifiable, physiological or psychometric terms (Selye, 1976; Greenwood, 1976; Fuller and Eliot, 1974; Cogan, 1976). Morgan and his colleagues (1969, 1971, 1976) have carried on the most persistent line of research in this area over the past 10 years with numerous studies on the acute and long-term effects of exercise on state anxiety in normal individuals and on patients with psychiatric illnesses. Morgan (1976) reported recently that vigorous physical activity produced significant decreases in state anxiety in "normal" and "clinically anxious" individuals. State anxiety levels were significantly increased during exercise at 80% of maximum V02, however within 10 min of recovery state anxiety was reduced to a level which was below the initial baseline. It was suggested that vigorous physical activity may be a practical and simple strategy for coping with stress.

Herbert deVries (1968, 1972) has also conducted a long and continuing series of experiments on the effects of exercise on physiological manifestations of anxiety, specifically muscle tension. He coined the terminology "tranquilizer effect of exercise" in an experiment where he found that 15 minutes of light to moderate exercise produced significantly lcwer levels of muscle action potential (i.e., muscle tension) than either the tranquilizer or the placebo treatments (deVries and Adams, 1972). Exercise at heart rate of 100 bts/min was equally as effective as more vigorous exercise at heart rate of 120 bts/min in reducing muscle tension.

Similar benefits, both subjective and physiological, have been reported concerning the use of meditation and other relaxation techniques to reduce the manifestations of state anxiety and muscle tension. The "relaxation response" is a term used to describe the hypometabolic changes which are observed during various meditative procedures (Beary and Benson, 1974). Oxygen consumption, carbon dioxide production and respiration rate were significantly reduced by a simplified relaxation technique called Benson's Meditation. This method is purportedly an effective means of coping with stress. However, very little evidence has been reported on the effectiveness of this technique in reducing physiological arousal associated with a very strong, real-life stressor. Similarly, the effect of exercise in this regard has never been examined. In fact, research on treatment procedures in the face of a very strong, real-life stressor is rare.

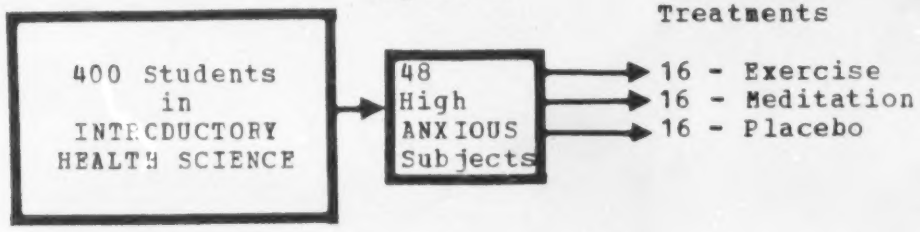
Therefore, the purpose of this investigation was to compare the effects of brief treadmill exercise and Benson's Meditation with a placebo-control treatment for reduction in several physiological and psycholcgical measures of stress, anxiety and tension before and after a written final examination in 48 high-test anxiety subjects. The final examination was selected because it is likely a very strong, real-life stressor.

METHODOLOGY

Subjects

Four hundred university students enrolled in an introductory health science course were screened via questionnaire for participation in a test anxiety experiment. Forty-eight students (24 male; 24 female; mean age = 19.7 yrs) were selected based upon self-reported high levels of test anxiety and excessive tension prior to and during written examinations (see Figure 1). Subjects agreed to take their final examination for the course individually in the laboratory.

Figure 1.



Room and Instrumentation

Students were seated in a comfortable armchair with a portable writing board across the chair in a well-lighted testing room (size = 9 X 12 feet). Instrumentation was located behind and out-of-sight of the student. Earphones were worn by all students to minimize the effects of extraneous laboratory noise. Electromyograph (EMG) activity from the frontalis muscle was recorded on a model E-2 Bio-Electric Information Feedback System, (Biofeedback Systems, Inc). The EMG reading (filtered to between 95-1000 Hz) was proportional to the area under the curve of half-wave rectified input voltage versus time. Frontalis muscle EMG was quantified digitally in peak-to-peak microvolts/minute. Surface electrodes were placed approximately one inch above the eyebrow and one and one-half inches on either side of the midline. A ground electrode was located between the reference electrodes directly above the nasion. The skin surface was cleaned thoroughly with acetone and the resistance between electrodes was always less the 10K. The raw EMG signal was

monitored continuously on an oscilloscope for presence of artifact or electrical interference.

Spontaneous fluctuations in skin resistance (EDR) were recorded on a Beckman polygraph. Beckman surface electrodes were placed on the palmar and dorsal aspect of the non-dominant hand. A ground electrode was placed on the forearm of the same arm and Beckman electrode paste was used for the interface between skin and electrode. The electrode cable was connected directly to the GSR pre-amplifier in the polygraph. Spontaneous (nonspecific) fluctuations of 200 ohms or greater were recorded for a one minute sample.

Heart rate (HR) was recorded from a bipolar electrocardiograph (ECG) tracing in the V5 position. Systolic (SYS) and diastolic (DIA) blood pressures were recorded on an automatic blood pressure device (Physiometrics).

A twenty-item questionnaire was utilized to assess state anxiety (Spielberger, 1969).

A portable motor-driven treadmill was located adjacent to the testing area for use as a mild (anticipation) stressor and for exercise treatment on one-third of the subjects.

Design and Procedure

1. Pre-treatment Data Collection. The forty-eight high test anxiety students were scheduled for a two-hour laboratory session which consisted of a brief treatment procedure followed by a written final examination. Initially, each student filled out the state anxiety questionnaire. Skin preparation and electrode placement for ECG, EMG and EDR were accomplished while the student was seated in the laboratory testing area. Following the ten minute rest period, two baseline measurements were recorded for HR, SYS, DIA, EMG and EDR. All subjects were then exposed to a mild stressor experience which consisted of watching the experimenter demonstrate walking on the treadmill. A general statement was made about the proper way to get onto the moving treadmill belt; but the statement was not directed to the student. It was assumed that the students might experience some arousal in anticipation of having to walk on the treadmill even though none of them were required to walk on the treadmill at that point in the experiment. HR, SYS, DIA, EMG and EDR were recorded immediately after the demonstration as a measure of the relative degree of arousal (lability response) from the baseline values.

2. Treatment Procedures. The forty-eight students were randomly assigned to one of three treatment procedures (N = 16/group) with the provision that equal numbers of males and females were represented (8 males, 8 females) in each group (see Figures 1 and

2). HR, SYS, DIA, EMG and state anxiety measures were taken after the 20 minute treatment period.

Figure 2.
TREATMENTS (Duration = 20 min.)

1) TREADMILL WALKING - Velocity adjusted to maintain heart rate = 100 - 110 bts/min.

2) BENSON'S MEDITATION - Sit quietly; close your eyes; relax muscles, repeat the word "ONE" to yourself everytime you exhale.

3) PLACEBO - Subjects took a pill purportedly double-blind; potentially a tranquilizer pill; in reality, a placebo.

The exercise treatment procedure consisted of walking on the treadmill at a speed and grade which elicited a heart rate response of 100-110 bts/min. In order to minimize the effects of fatigue and sympathetic stimulation of exertion, an interval design was utilized. Students walked for four minutes, rested one minute, walked three minutes, rested one minute and walked another three minutes for a total of ten minutes walking within a twelve minute period (see Figure 3). During the recovery period (eight minutes) the subjects were seated and were told to relax as much as possible.

Figure 3. EXERCISE TREATMENT:
Treadmill Walking at Heart
Rate = 100 - 110 bts/min

Walking	Rest	Walking	Rest	Walking		Time
4 min	1 min	3 min	1 min	3 min	=	12 minutes
RECOVERY PERIOD: Subjects were told to relax as much as possible						8 minutes
TOTAL DURATION OF TREATMENT					=	20 minutes

The meditation treatment procedure was a westernized version of Transcendental Meditation called Benson's Meditation. The instructions for the group were adapted from Beary and Benson (1974).

> Sit quietly in a comfortable position. Close your eyes. Deeply relax all of your muscles, beginning at your feet and progressing up to your face. Keep them deeply relaxed. As you breath out, say the word "ONE" silently to yourself. For example, breath IN ... OUT, "ONE", IN ... OUT, "ONE". Continue until told to stop. Do not worry about whether you are suceeding in achieving a deep level of relaxation. Maintain a passive attitude and permit relaxation to occur at its own pace. If distracting thoughts do occur, ignore them and continue to repeat "ONE".

At two minute intervals during the 20 minute procedure, the subjects were asked to give a comparative estimate of facial tension for assessment of psychophysiological awareness (data not reported here). Each time the students were interrupted for an estimate, they were asked if they had been following the procedure (as opposed to having been daydreaming) and they were then reminded to continue following the meditative procedure.

The placebo treatment procedure consisted of having the subjects take a pill and then sit quietly relaxing for twenty minutes. The students were told that the pill was either: 1) a tranquilizer which could have a relaxing effect or 2) a placebo which would have no effect. The experiment was purportedly double-blind, with the explanation that neither the experimenter nor the subject would know whether the pill was a tranquilizer or a placebo. The pill was, in fact, a placebo; no tranquilizers were administered. These students were also interrupted every two minutes for an estimate of facial tension, however nothing was said about daydreaming as compared to the instructions to avoid daydreaming for the meditation group.

3. Data Collection During and After the Examination. During the examination HR, SYS, DIA and EMG were recorded at six minute intervals until the student finished. Upon completion of the examination, each student was asked to sit quietly and relax for a few minutes. Post-examination data for HR, SYS, DIA, EMG and state anxiety were then recorded. During the post-examination data collection period, the student's objective examination was being graded. The student was informed that his or her grade would be available in a few minutes. It was assumed that the students might experience some additional level of arousal in anticipation with some degree of excitement or anxiety over the impending outcome (grade) from their examination. Just before the graded examination was returned, each student was asked

directly if he or she had seen this examination previously or if he or she had gotten any assistance prior to the examination from any other student. The purpose of the question was to elicit an "arousal response" from those students who might show post-examination labile characteristics in any one or more of the physiological parameters. The final measurements for HR, SYS, DIA and EMG were recorded at this time. Physiological data recorded during and after the examination are not reported here.

RESULTS

The combined data for all 48 subjects before randomization are shown on Figures 4 and 5. A t-test was performed between pre-experiment baseline measurements and poststressor measurements for SYS, DIA, HR, EMG and EDR. During the stressor experience, the subject sat quietly while he or she observed the experimenter starting the treadmill and walking on it briefly. Physiological data was collected after the treadmill was stopped. Significant increases above baseline were noted for all parameters except diastolic blood pressure. These results confirmed the underlying assumption in this experiment that the majority of the physiological parameters (SYS, HR, EMG and EDR) were positively responsive to a mental load and therefore might also be negatively responsive to a treatment procedure.

The treatment effects of exercise, meditation and placebo on HR after pre-experiment baseline and the stressor (anticipation) are shown in Figure 6. Post-treatment means were adjusted by analysis of covariance (values for pre-training and stressor = covariates). A significant treatment effect was observed between groups, $F(2,43) = 6.66$, $MSe = 0.003$. A post-hoc analysis of the differences (Newman-Keuls) showed that the mean HR for the exercise group was significantly lower than for the placebo group. Thre was no significant difference in the group means between the exercise and meditation treatments or between the meditation and placebo treatments.

The treatment effects on EMG after the pre-experiment baseline and the stressor are shown in Figure 7. The analysis of covariance showed a significant treatment effect between groups, $F(2,43) = 13.18$, $MSe = 0.115$. The post-hoc analysis showed a significant difference between the exercise treatment and the placebo treatment and between the meditation treatment and the placebo treatment. There was no significant difference between the exercise and meditation treatments.

The treatment effects on EDR after the baseline and the stressor are shown in Figure 8. The analysis of covariance revealed a significant treatment effect among groups, $F(2,43) = 3.15$, $MSe = 1.207$. The post-hoc analysis showed that only the exercise group was significantly lower than the placebo group for this parameter.

In the statistical analysis of the systolic and diastolic blood pressure data, there were no significant treatment effects observed for any of the groups.

State anxiety data was collected only pre-experiment, post-treatment and after the completion of the experiment (Figure 9). Both exercise and meditation groups showed a marked decrease in state anxiety following treatment and the ANOVA showed that there was a significant main effect for periods, $F(2,90) = 12.7$, $MSe = 59.6$. The main effect for groups was just short of significance, $F(2,45) = 2.9$, $MSe = 142.0$, however the groups X periods interaction was not significant. Although there appears to be a group difference for state anxiety, the ANOVA showed that neither experimental groups was significantly lower than the placebo group following treatment.

DISCUSSION

A large body of information has been accumulated on the nature and treatment of test anxiety (Spielberger, Anton and Bedell, 1976). The vast majority of the research has dealt with the cognitive factors in personality which characterize the high test anxiety student who performs poorly on examinations. An equivalent amount of research has been devoted to the effectiveness of various treatment procedures for reducing test anxiety and improving performance. The most common treatment packages include group counseling, systematic desensitization and cue-controlled relaxation usually conducted over 5-10 sessions (Russel, Wise and Stratoudakis, 1976; Deffenbacher, 1976; Speilberger, et al., 1976). Very little work has been reported on treatment packages which utilize a brief but intense procedure immediately prior to the examination to reduce test anxiety and its physiological manifestations.

The experiment described in this paper was designed to compare the effectiveness of two very diverse treatments in reducing both physiological and psychological indicators of stress in high test anxious students immediately prior to a written final examination. It is unique in that: 1) the subjects were selected from a homogeneous population of 400 students taking the same university course, 2) the subjects were randomly assigned to treatments, 3) both physiological and psychological data were collected and 4) the examinations, treatments and evaluations were conducted in a controlled laboratory environment.

Physical activity has been utilized previously as a method of reducing state anxiety (Morgan, 1976) and muscle tension (deVries; 1972). The results were extremely encouraging, however the treatments were not administered in the face of an acute, real-life stressor such as a final examination. Therefore, it is particularly encouraging to note in the present investigation

that three separate measures of autonomic and skeletal-muscle arousal (HR, EDR and EMG) were significantly lower in response to exercise treatment than for placebo treatment. These results were observed in students who were anticipating a relatively intense real-life stressor, i.e., a final examination. In addition, it should be noted that Morgan (1976) utilized relatively intense exercise (80% of V02 max) to achieve reductions in state anxiety. Comparing these results to the present investigation where the intensity of exercise was closer to 50% of V02 max (procedures similar to the study by deVries and Adams, 1972) the modest treatment effects of the treadmill walking on state anxiety are perhaps not surprising. Gal and Lazarus (1975) have discussed the role of activity in coping with stressful situations. They concluded that activity during stressful situations did, in some cases, increase physiological arousal, however psychological stress was reduced. The participants usually preferred activity, perhaps as a method of reducing anxiety and dissipating the tension which had developed.

It is interesting to note that the meditation treatment was equally as effective in reducing EMG as the exercise treatment. Numerous other investigators have observed remarkable decreases in muscle tension in response to various forms of relaxation training (Paul, 1969; Bernthal and Papsdorf, 1975; Jacobson, 1938, Sime and DeGood, 1977). However, the majority of these studies have observed reductions in EMG after an extended training program. The results for the meditation treatment in the present investigation are compromised somewhat by the absence of concomitant reductions in the other measures of autonomic arousal (HR and EDR). The fact that exercise did show a significant reduction in all three variables (HR, EDR and EMG) may be due in part to the fact that it was an active coping mechanism. Gal and Lazarus (1975) found that subjects preferred an active role in coping with a stressful situation. Thus it is perhaps not surprising that the meditation group did not exhibit more dramatic effects. This conclusion is based upon the fact that Benson's procedure specifies the requirement of passive attitude by the participants. Our students anticipating a final examination certainly may have been anything but passive.

The results of this experiment could also be interpreted as a demonstration of a powerful placebo effect in that the reductions in SYS and DIA among groups were equivalent. The students in the placebo group were convinced that they may have taken a tranquilizer and they had a full 20 minute rest period with some diversion from cognitive anxiety prior to the examination. These conditions have been shown to produce expectancies for treatment effects which often become marginally potent (Valee and Levine, 1975). This factor may be even more relevant in the population studied, since the high anxious student is probably more vulnerable than the low anxious student to positive outside influence (suggestion of a relaxation effect) as well as negative, internal, task-irrevalent responses.

In summary, this experiment has illustrated preliminary evidence indicating that brief mild exercise may be effective in coping with acutely stressful situations. If exercise is, in fact, an effective coping mechanism, then it might also be found more or less effective in diverse populations. Further investigations are needed to identify additional coping strategies which are effective in reducing inappropriate physiological and psycholcgical responses to real life stressors. Careful consideration must be given to the placebo effect and to the incorporation of an appropriate control population. Future studies may find success with some variation in the duration, frequency or intensity of the treatment, as well as in a possible hybridization of treatments.

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Figure 4. Heart rate, systolic and diastolic blood pressure for all 48 students during pre-experiment baseline and after the mild stressor (anticipation).

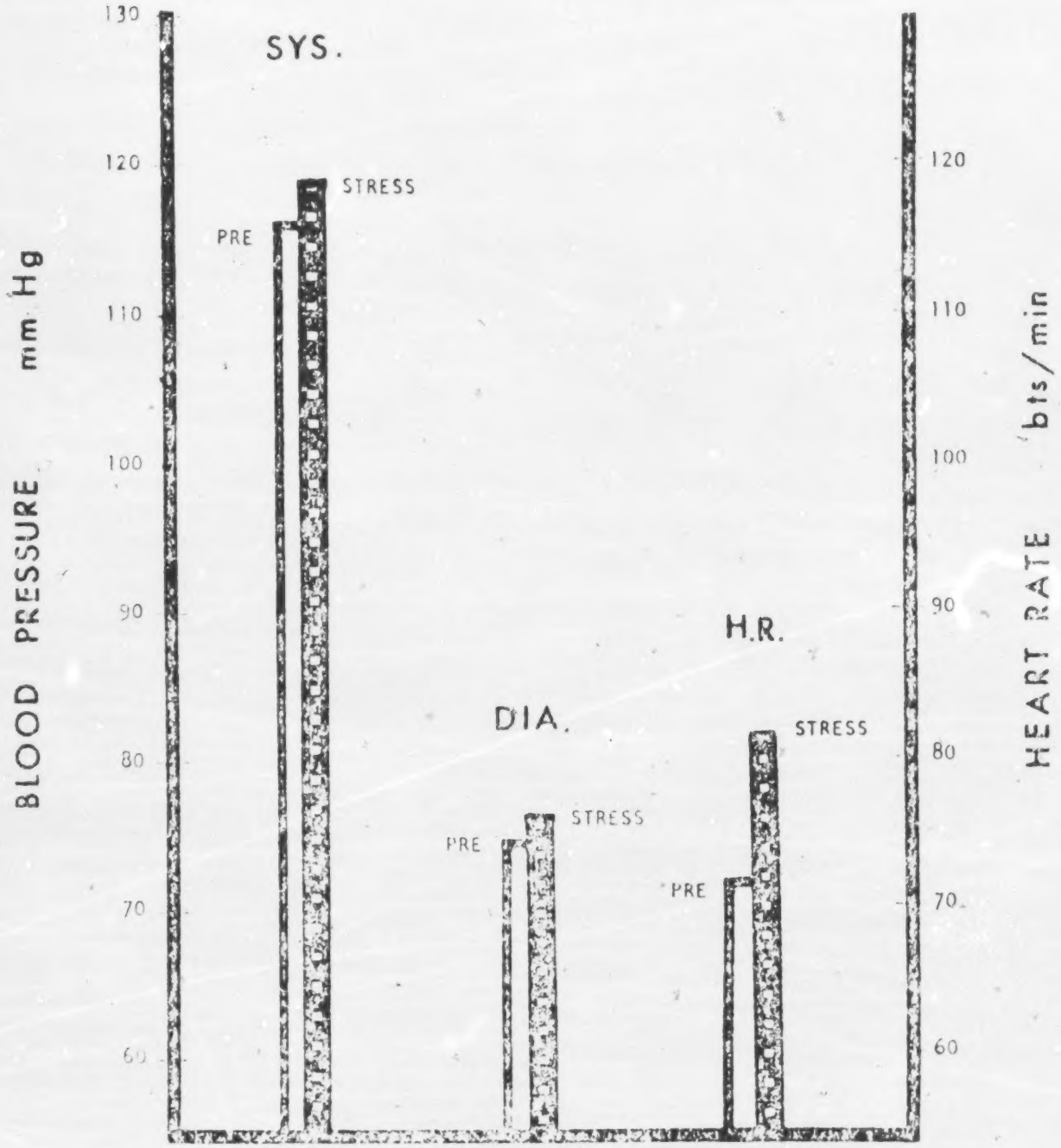
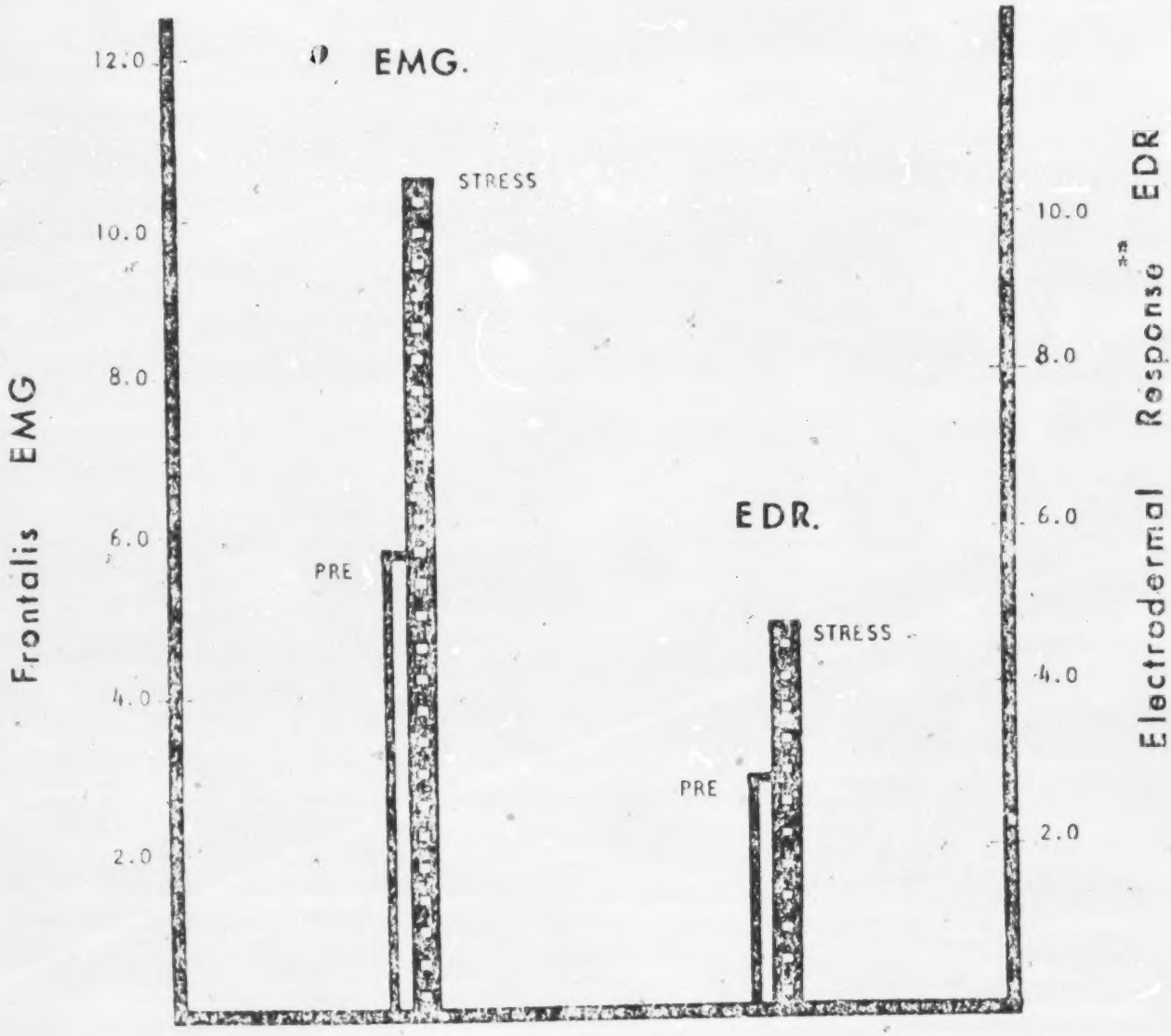


Figure 5. Frontalis muscle EMG and spontaneous fluctuations in electrodermal response for all 48 students during pre-experiment baseline and after the mild stressor (anticipation).



* Integrated electromyography of frontalis muscle in uvolts per minute.

** no. of spontaneous fluctuations in electrodermal response.

Figure 6. Heart rate at baseline pre-experiment and in response to stressor (anticipation) and treatment for placebo, exercise and meditation (N=16/group).

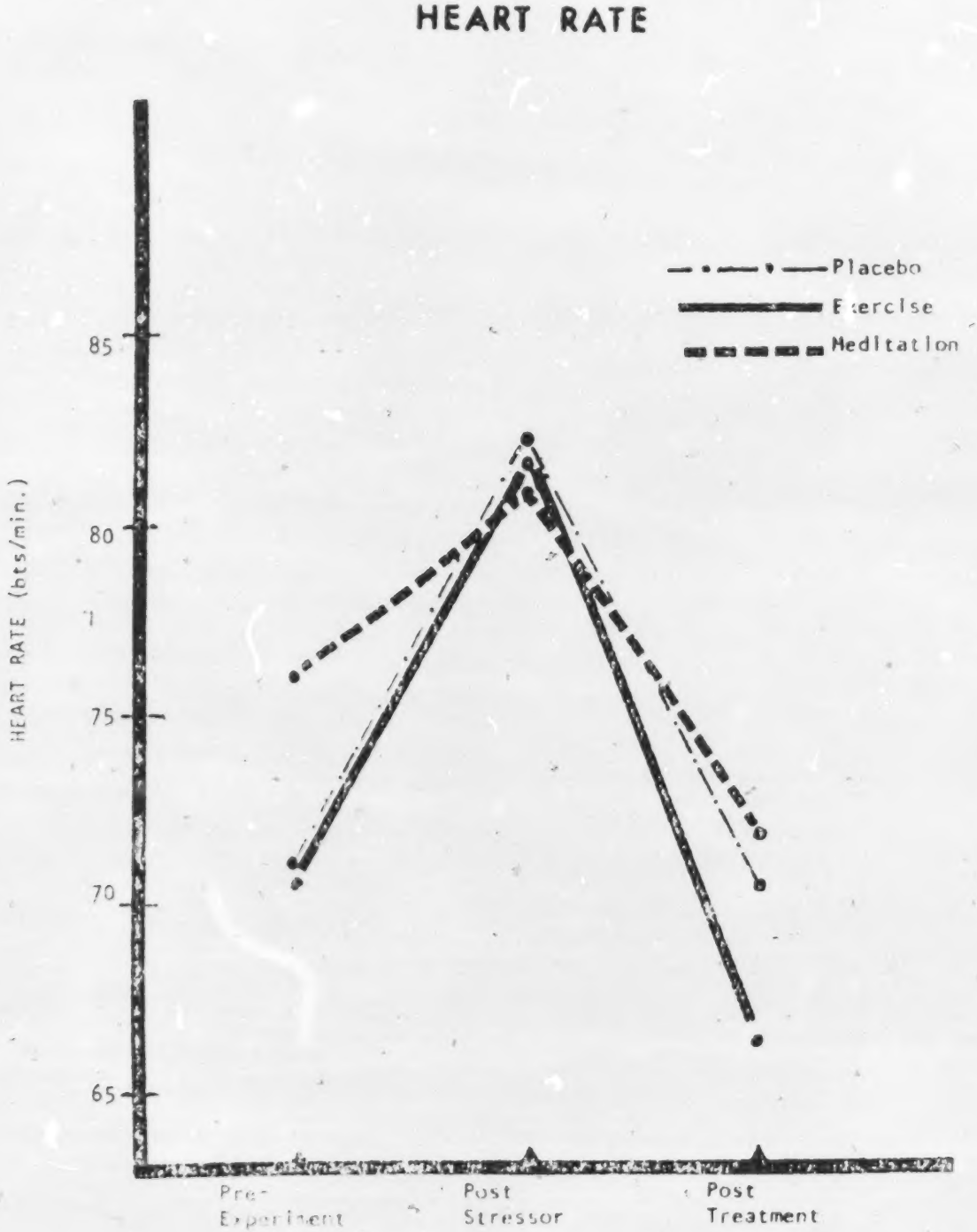


Figure 7. Frontalis muscle tension at baseline pre-experiment and in response to stressor (anticipation) and treatment for placebo, exercise and meditation (N=16/group).

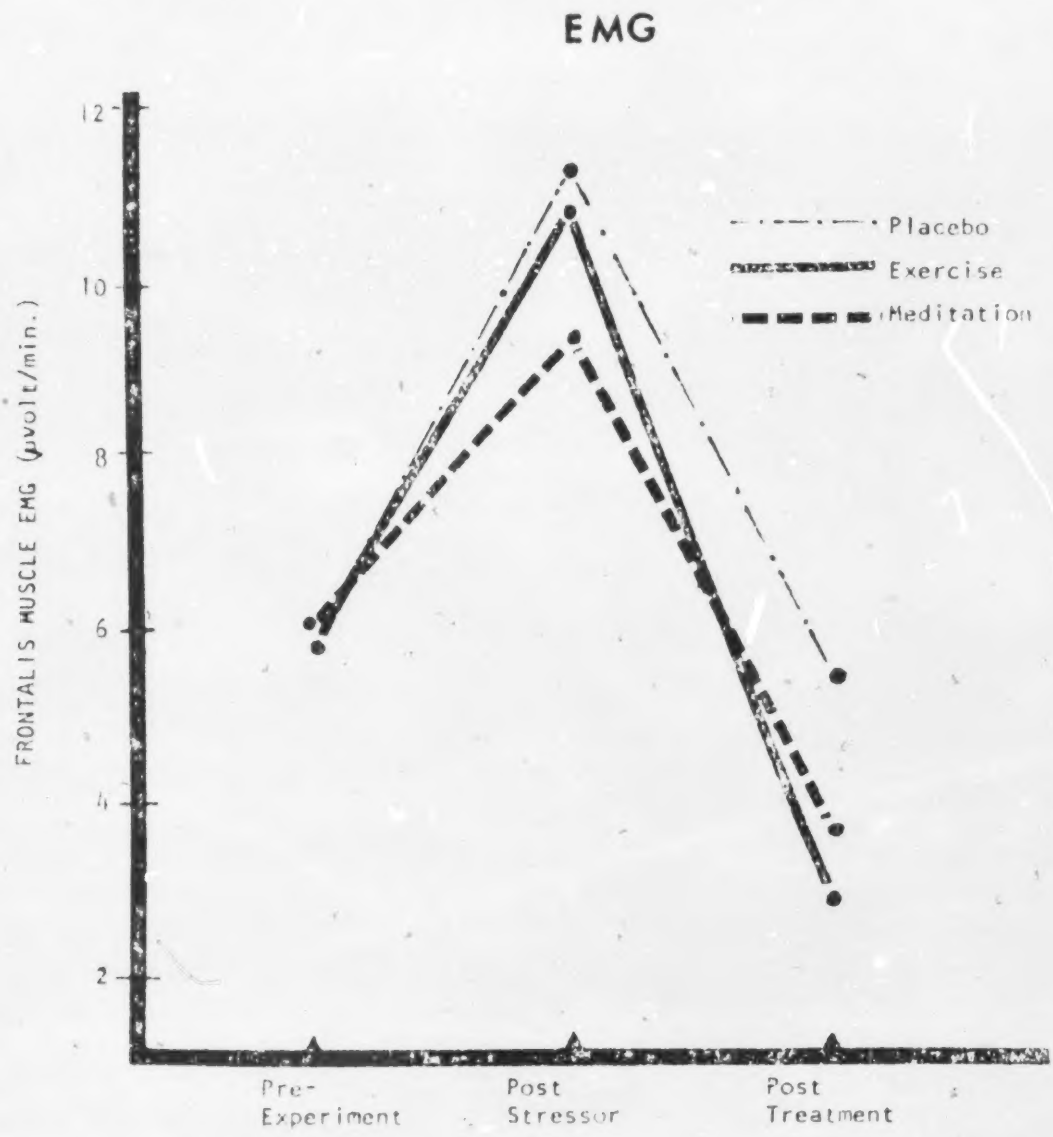


Figure 8. Spontaneous fluctuations in electrodermal response at baseline pre-experiment and in response to stressor (anticipation) and treatment for placebo, exercise and meditation (N=16/group).

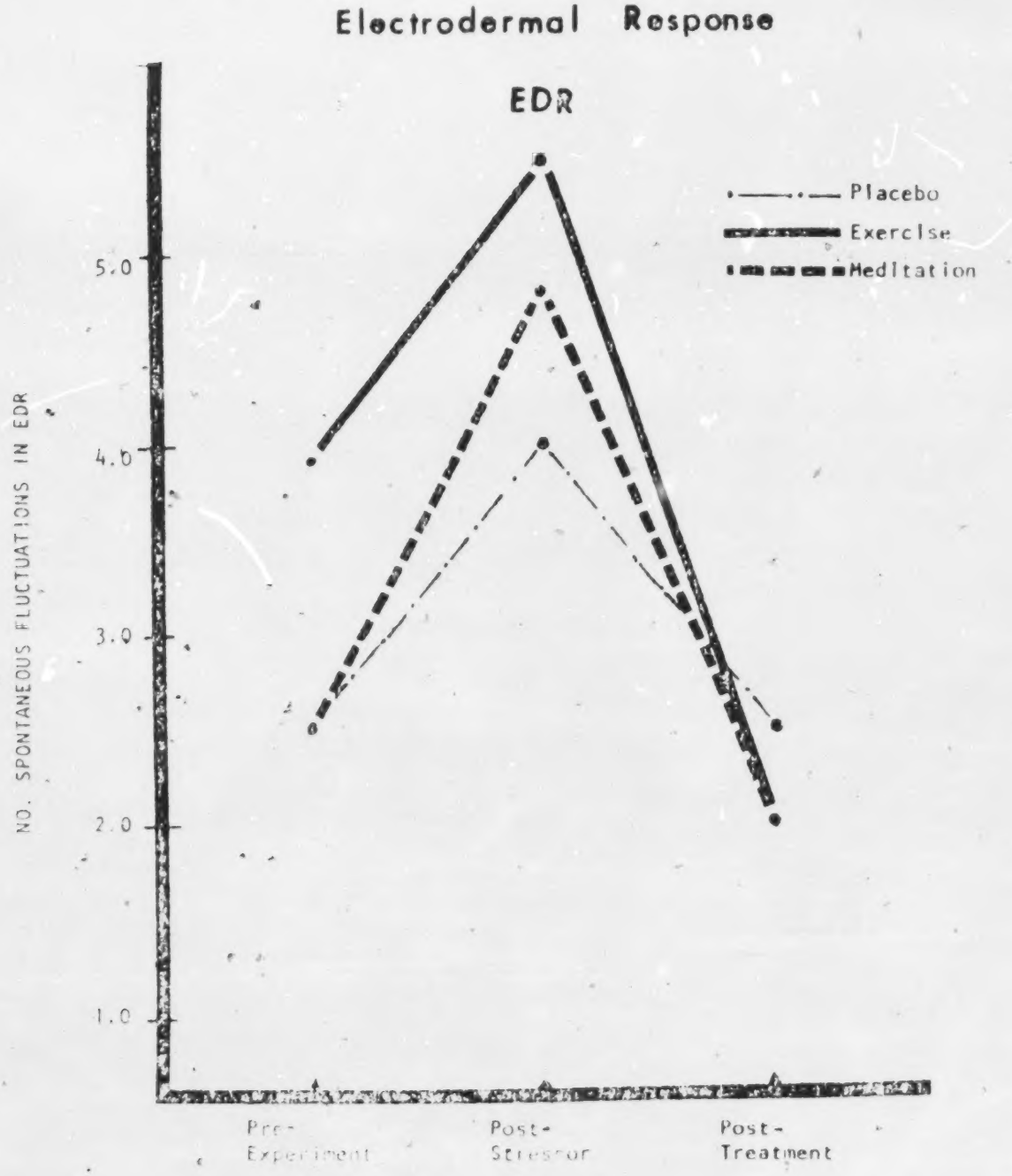


Figure 9. State anxiety at baseline pre-experiment, post-treatment and post-experiment for placebo, exercise and placebo groups (N=16/group).